INDOOR AIR QUALITY ASSESSMENT

Massachusetts Division of Health Care Finance & Policy
China Trade Building
2 Boylston Street
Boston, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
May 2005

Background/Introduction

At the request of Michael Berolini, Director of Administration/Chief Financial Officer for the Division of Health Care Finance & Policy (DHCFP), the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding conditions at the DHCFP offices located at the China Trade Center (CTC), 2 Boylston Street, Boston, MA. Concerns about odors from new carpeting, floor dividers and demolition of interior building materials (e.g., gypsum wallboard) prompted the request. On February 28, 2005, a visit to conduct an indoor air quality assessment was made by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), CEH. Issues related to renovation activities were addressed in a separate letter provided by MDPH, dated March 16, 2005 (MDPH, 2005).

The CTC was originally constructed in the early 1900's. An addition was built on the alleyway side of the building in the 1980s (Picture 1) as part of an overall rehabilitation of the building. At that time, a large multi-story atrium was also added to the building (Picture 2). The ground and first floor are occupied by a variety of commercial business. Floors three through six serve as office space for Massachusetts state agencies. The division of DHCFP occupies the entire fourth and fifth floors and limited space on the sixth floor. The DHCFP office space consists of numerous private offices as well as cubicles created by floor dividers. Windows are openable throughout the DHCFP offices examined.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor. Screening for total volatile organic compounds (TVOCs) was conducted using an HNu Photo Ionization Detector (PID). Tests were taken during normal operations and are shown in Table 1.

Results/Discussion

Ventilation

It can be seen from Table 1 that the carbon dioxide levels were above 800 parts per million (ppm) in twenty-three of thirty-four areas surveyed, indicating less than adequate air exchange a number of areas surveyed, with the majority on the fourth floor. Fresh air appears to be introduced from an air-handling unit (AHU) on the roof (Picture 3), which is then vented into the space between the suspended ceiling and the original ceiling (called the ceiling plenum). Heat pumps located above the suspended ceiling on each floor draw from the ceiling plenum and distribute air to occupied areas by ceiling-mounted air diffusers. Return air from occupied space is drawn through ceiling mounted grilles back to the AHUs. It appears that the sole mechanical source of fresh air for the offices area is the rooftop unit in Picture 3. It is likely that fresh air supply was intended to be supplemented by opening windows, which would make temperature control in the heating season difficult. No other independent source of mechanically supplied outdoor air could be identified by MDPH staff.

An exhaust motor for restrooms was observed on the roof (Picture 3). The rooftop AHU was also examined and did not appear to have any means for exhaust air. No other means of mechanical exhaust ventilation could be identified on the roof. Therefore, it appears that the sole method to mechanically exhaust air from the building is via the restroom vents. Each restroom is equipped with one ceiling-mounted exhaust vent. The restroom doors are equipped with a transfer air vent, which draws air from the hallway. Restrooms are located in a central area on each floor, which would facilitate the draw of air from hallways, and indirectly cubicle areas and offices. This design provides limited exhaust ventilation and can allow common indoor pollutants (e.g., carbon dioxide exhaled from occupants, odors from cooking appliances) to build-up inside the building and be continuously recirculated by the heat pumps leading to indoor air/comfort complaints.

In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). It was reported to MDPH staff that during the 1997 renovations balancing of the ventilation systems for the DHCFP was planned (MDPH, 1997). Information as to whether the ventilation system was balanced during the renovations was not available.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature readings ranged from 69° F to 77 ° F, which were within the MDPH recommended comfort guidelines in all but one area, which was an office where occupants preferred cooler temperatures. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity readings ranged from 15 to 20 percent, which were below the MDPH recommended comfort range the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several areas had a number of plants. Plant soil, standing water and drip pans can be potential sources of mold growth. Drip pans should be inspected periodically for mold growth and over watering should be avoided.

Other Concerns

As mentioned previously, findings and recommendations pertaining to renovation activities were detailed in a previous letter issued by MDPH (MDPH, 2005). Several other conditions that can affect indoor air quality were also identified. Of particular note is the configuration of the ventilation system. The HVAC system uses a ceiling plenum system to return air to heat pumps located above the suspended ceiling (Picture 4). Air is returned to the heat pump via the space between the suspended and original ceilings (a ceiling plenum). As the heat pump operates, air is drawn into the pump through the ceiling plenum, which in turn depressurizes the plenum to draw air from the occupied spaces through return grilles in the ceiling.

The suspended ceiling consists of ceiling tiles that are made of foam polystyrene, an extremely light plastic material. In most areas examined, ceiling tiles were dislodged from the ceiling supports (Picture 5 and 5a) by either the draw of air by the heat pumps or by pressurization of the occupied space when windows are open. The dislodgement of ceiling tiles is most likely due to the lightweight ceiling tile materials, which do not have the same weight as typical cellulose ceiling tiles to hold them in place. Dislodged tiles/breaches in the ceiling tile system decrease the efficiency of the plenum system to draw air, which can produce uneven heating/cooling leading to temperature/comfort complaints.

A variety of locations of the ceiling plenum were examined. Open penetrations in the original ceiling were noted. Since the heat pumps depressurize the ceiling plenum, materials (e.g., particulates, odors) above the original ceiling or wall space can then be drawn into the plenum and distributed into occupied areas by the heat pump. Ceiling plenums should be sealed a much as practicable in order to prevent this occurrence. Each heat pump is connected to an air diffuser by a flexible duct that is connected to a rigid, metal duct. The plenum above the sixth floor bullpen area was examined due to noise above the ceiling. In the area of the noise, flexible ductwork was dislodged from the metal supply duct (Picture 6). This disconnection prevents distribution of air to this area and may account for the vibrating noise.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1. Implement the recommendations made in the March 16, 2005 letter.
2. Examine the ceiling plenum for disconnected flexible ductwork on each floor and repair as needed.
3. Identify the means by which the general ventilation system exhausts air from the building and operate the system during business hours. If no means to provide general exhaust ventilation exists, consult a ventilation engineer on the most appropriate method to install a general exhaust ventilation system and move forward with installing this equipment.
4. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
5. Examine feasibility of providing exhaust ventilation for break rooms with cooking appliances.
6. Ensure restroom exhaust vents are operating during business hours to remove odors and excess moisture.
7. Consideration should be given to replacing foam polystyrene ceiling tiles with a heavier type in order to help maintain the integrity of the ceiling plenum system.
8. Consider reducing the number of plants in work areas. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.

9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations). Consider obtaining a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter to trap respirable dusts.

References

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MDPH. 1997. Memorandum to Suzanne Condon, Director, Bureau of Environmental Health Assessment from Michael Feeney, Chief, Emergency Response/Indoor Air Quality Program concerning Proposed renovation at the Div. of Health Care Finance & Policy, 2 Boylston Street, Boston, MA Dated July 16, 1997. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

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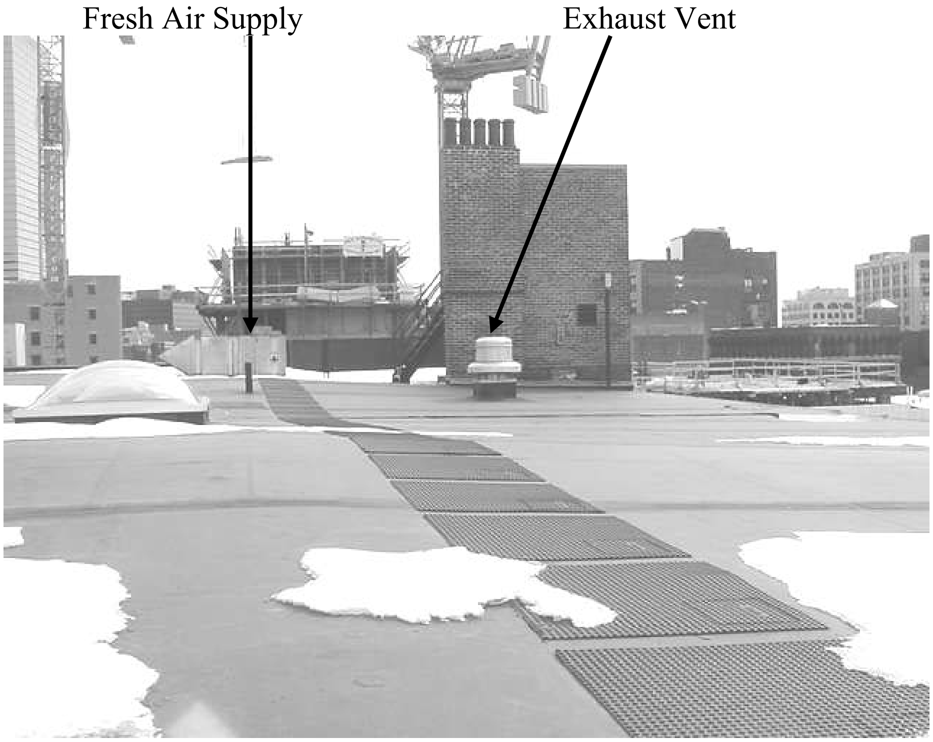
Picture 1

Addition to Rear of Building

Picture 2

Atrium inside the Building

Picture 3



Rooftop AHU and Likely Restroom Exhaust Fan On Roof

Picture 4

Ceiling Plenum above Suspended Ceiling

Picture 5

Dislodged Ceiling Tiles

Picture 5A

Close-up of Dislodged Ceiling Tile

Picture 6

**Flexible Supply Air Duct Disconnected From Metal Duct
In Sixth Floor Ceiling Plenum**

TABLE 1
Massachusetts Division of Health Care Policy and Planning
2 Boylston Street, Floors 4-6
Boston, Massachusetts
February 28, 2005

Location	Floor	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	TVOC (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Outside (Background)		410	42	17	ND					
Commissioner reception	5	651	70	18	ND	2	Y	Y	Y	Photocopier
McCabe Office	5	652	71	18	ND	1	Y	Y	Y	Dry erase board Door open
Main reception	5	602	72	16	ND	0	Y	Y	Y	Wood-like odor
Commissioner Conference room	5	605	72	16	ND	0	Y	Y	Y	Dry erase board Door open
Panaro office	5	628	72	15	ND	0	N	Y	Y	Door open
File area	5	635	71	16	ND	0	N	U	U	Laserjet printer
Borgella Office	5	767	69	17	ND	1	N	Y	Y	Door open
Allenby office	5	788	70	17	ND	7	N	Y	Y	Plants Door open

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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								Supply	Exhaust	
Campeau/Hines office	5	880	74	18	ND	2	Y	Y	Y	Plant
Hallway to Main Cubicle Area	5	771	71	19	ND	0	N	Y	Y	Photocopier Laserjet printer Wood-like odor
Main Cubicle Area- North aisle	5	869	72	20	ND	4	Y	Y	Y	
Wessman office	5	878	73	20	ND	1	Y	Y	Y	Door open
Kane office	5	923	73	19	ND	2	Y	Y	Y	Dry erase board 1 ajar ceiling tile
Main Cubicle Area- center aisle	5	985	73	17	ND	6	Y	Y	Y	Plant
Main Cubicle Area-aisle with cubicles on both side	5	941	73	17	ND	6	Y	Y	Y	
Main Cubicle Area-south aisle	5	889	73	17	ND	2	Y	Y	Y	

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Westwater office	5	969	73	17	ND	1	Y	Y	Y	Plant Door open
Daley Office	5	667	70	15	ND	1	Y	Y	Y	Door open
O'Brien office	6	697	72	16	ND	1	Y	Y	Y	1 ajar ceiling tile
Reception	4	870	74	16	ND	1	Y	Y	Y	Wood-like odor Photocopier
Rating cubicles	4	919	73	16	0.2-0.4	3	Y	Y	Y	1 missing ceiling tile
Team Room	4	906	73	16	0.2-0.4	0	N	Y	Y	2 missing ceiling tiles
Police cubicles	4	959	73	16	0.2-0.4	3	Y	Y	Y	
Grenier office	4	993	73	17	0.2-0.4	1	Y	Y	Y	Door open
Brandt office	4	998	73	16	0.2-0.4	1	Y	Y	Y	Plants Door open
Northwest corner cubicles	4	920	73	16	ND	4	Y	Y	Y	Plants

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								Supply	Exhaust	
Vending machines area	4	941	76	18	ND	N	Y	Y	Y	
Break room	4	877	76	16	ND	0	N	Y	Y	No exhaust vent 2 microwave ovens
Records room	4	832	77	17	ND	0	N	Y	Y	
Main Cubicle Area- north aisle	4	912	76	15	ND	0	Y	Y	Y	5 ajar ceiling tiles
Lohr office	4	910	76	16	ND	0	Y	Y	Y	Door open
Main Cubicle Area- center aisle	4	862	76	15	ND	0	Y	Y	Y	
Main Cubicle Area- south east	4	887	76	15	ND	8	Y	Y	Y	
Conference room	4	959	76	16	ND	0	N	Y	Y	Door open

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